COMPARATIVE BIOLOGICAL STUDIES OF FOUR *DIPLODUS* SPECIES (PISCES, SPARIDAE).

by

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ABSTRACT. – Eighteen biometric characters, length/weight relationships and condition factors of *Diplodus annularis* (L) and *Diplodus cervinus* (Lowe) inhabiting the Egyptian Mediterranean waters were studied. Results were compared with those previously obtained for the other two local *Diplodus* species, namely : *Diplodus sargus* and *Diplodus vulgaris*. Age and growth rates of *D. annularis* were determined using the scales. Growth in length as well as in weight were followed until the sixth year of life and compared with that already estimated for *D. sargus* and *D. vulgaris*.

RÉSUMÉ. – L'auteur étudie 18 caractères biométriques, les relations longueur/poids et le facteur de condition chez *Diplodus annularis* (L.) et *Diplodus cervinus* (Lowe) dans les eaux côtières d'Egypte. Les résultats ont été comparés à ceux précédemment obtenus pour les deux autres espèces du genre présentes dans ces eaux : *Diplodus sargus* et *Diplodus vulgaris*. L'âge et le taux de croissance de *D. annularis* ont été déterminés par scalimétrie. Les croissances en longueur et en poids ont été suivies jusqu'à l'âge de six ans et comparées avec celles déjà estimées par *D. sargus* et *D. vulgaris*.

Key-words : *Diplodus annularis, Diplodus cervinus*, Sparidae, Pisces, biométrics, growth.

Seabreams or porgies (Family Sparidae) constitute an important fishery resource along the Egyptian Mediterranean coasts. Genus *Diplodus* (*Sargus*) is represented by four species inhabiting our local waters : *Diplodus sargus* (L., 1758); *D. vulgaris* (Geoff., 1817); *D. annularis* (L., 1758) and *D. cervinus* (Lowe, 1841) (2). They are also widespread in the whole Mediterranean (Tortonese, 1965). From the preceeding four species, the first two were thoroughly studied, biometrically as well as biologically, (Wassef, 1973). Also, Kamel (1978) gave the systematic position, brief description and synonyms of the four *Diplodus* species among other sparid fishes collected from the Egyptian Mediterranean waters.

Very few papers were available on the biology of *D. annularis* and *D. cervinus* in other areas. However, the works of Wassef (1973) and Kamel (1978) are the

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only local investigations available. The present work deals with the biometric analyses of *D. annularis* and *D. cervinus* with the aim of clarifying the identity of local populations. Besides, it includes comparative biological data which is essential to know in order to improve fishery management techniques in our waters.

MATERIALS AND METHODS

Random samples were collected from the commercial catches at Alexandria eastern harbour center, where the fishing boats landed their catch. Bottom trawls and long lines are the main gears used for capturing these fishes. Sampling extended from November 1980 to October 1981 for *D. annularis* and to July 1981 for *D. cervinus*. The former species was available most the year around except in March and rare in April and May, while the latter was generally of less occurrence or absent from the commercial catches in August, September and October. *D. annularis* ranged in total length between 7-17 cm and *D. cervinus* between 11-37 cm. Fish were taken fresh to the laboratory for analysis. Fifteen morphometric measurements were recorded (to the nearest mm) and three meristic characters were counted for each individual fish for both species, according to the standard scale mentioned by Wassef (1973). Total weight, sex and maturity stage were also assessed for each specimen. A number of scales were taken from just behind the pectoral fin below the lateral line for age determination. Later, they were cleaned and mounted dry between two glass slides and examined under a binocular microscope (magnification X 16). Age was estimated by counting the annuli « winter checks » on the scales. Most annuli appear distinctly dark in transmitted light, and this characteristic with « cutting-over » when present was used to distinguish true annuli. With the aid of eye piece micrometer, distances from the focus to each annulus and to the marginal end of the scale were measured on the anterior diagonal line. Because most of fish examined were either sexually undifferenciated or hermaphrodites, analyses of data were achieved for both sexes together.

RESULTS

BIOMETRIC ANALYSIS

Morphometric characters

Ratio indices

The morphometric index of each measurement was calculated, for every fish, as a numerical ratio between this measurement and the total length (TL). The average values of these indices for every cm length group and for all length groups were obtained for *D. annularis* and *D. cervinus*. The head length (HL) was taken as a reference length for snout length (SnL), eye diameter (ED) and interorbital (InO). The range and average values were compared with those recorded by Wassef (1973) for *D. sargus* and *D. vulgaris* in Table I. The other measurements recorded were the preanal length (PRA), predorsal length (PRD), preventral length (PRV).

Table I. – Ratio indices range and average of the four *Diplodus* species. Between brackets : number of fish analysed.

Ratio index	*D. annularis* (379)		*D. cervinus* (85)		*D. sargus* (462)		*D. vulgaris* (263)	
	range	$\bar{m}$	range	$\bar{m}$	range	$\bar{m}$	range	$\bar{m}$
TL/SL	1.29 - 1.31	1.31 ± –	1.31 - 1.37	1.34 ± 0.02	1.28 - 1.36	1.32 ± 0.06	1.31 - 1.4	1.35 ± 0.03
TL / BB	2.71 - 2.98	2.81 ± 0.08	2.45 - 3.67	2.54 ± 0.07	2.48 - 2.68	2.58 ± 0.07	2.63 - 2.77	2.7 ± 0.05
TL / HL	3.92 - 4.35	4.08 ± 0.13	3.64 - 4.48	4.18 ± 0.2	3.82 - 4.09	3.95 ± 0.10	3.89 - 4.2	4.04 ± 0.08
TL / PRA	1.83 - 1.94	1.87 ± 0.03	1.88 - 2.0	1.95 ± 0.04	1.81 - 1.98	1.89 ± 0.11	1.96 - 2.07	2.01 ± 0.02
TL / PRD	3.46 - 3.76	3.55 ± 0.08	3.42 - 3.79	3.62 ± 0.13	3.46 - 3.79	3.63 ± 0.05	3.51 - 3.87	3.69 ± 0.02
TL / PRV	3.26 - 3.5	3.40 ± 0.08	3.21 - 3.75	3.41 ± 0.14	3.32 - 3.68	3.50 ± 0.08	3.32 - 3.52	3.42 ± 0.08
TL / DFL	2.24 - 2.41	2.31 ± 0.05	2.35 - 2.61	2.43 ± 0.07	2.13 - 2.34	2.23 ± 0.08	2.29 - 2.59	2.43 ± 0.08
TL / PRFL	3.57 - 3.82	3.68 ± 0.08	5.71 - 6.54	6.07 ± 0.2	3.19 - 3.84	3.51 ± 0.03	3.31 - 3.58	3.44 ± 0.06
TL / AFFL	5.18 - 5.65	5.43 ± 0.17	3.54 - 3.96	3.72 ± 0.11	5.12 - 5.57	5.34 ± 0.10	4.93 - 5.31	5.12 ± 0.05
HL / SnI	2.26 - 2.63	2.46 ± 0.11	2.32 - 2.66	2.52 ± 0.16	2.11 - 2.69	2.4 ± 0.09	2.32 - 2.66	2.49 ± 0.05
HL / ED	2.9 - 3.33	3.09 ± 0.13	3.33 - 3.78	3.58 ± 0.14	2.92 - 5.0	3.96 ± 0.05	2.62 - 3.89	3.26 ± 0.04
HL / InO	3.12 - 3.36	3.25 ± 0.07	2.88 - 3.33	3.0 ± 0.13	2.78 - 3.15	2.96 ± 0.04	3.04 - 3.33	3.19 –0.03–
PdL / Pdd	1.44 - 1.64	1.54 ± 0.06	1.42 - 1.73	1.52 ± 0.08	2.78 -	–	–	–

Morphometric regression

The linear regression equation $Y = a+bX$ was used to obtain the formulae representing the relation between total length TL and each morphometric character respectively. In this equation Y = morphometric measurement (in mm), X = total length (in mm), a and b are constants which can be determined using the statistical method of least squares.

The respective equations for six morphometric characters were calculated for both species and compared with those, previously derived by Wassef (1973), for *D. sargus* and *D. vulgaris* in Table II. Regression equations were used to obtain the calculated morphometric measurements. A close agreement between the observed and calculated values proved the fitness of the deduced equations.

Table II. – Regression equations for the four *Diplodus* species.

Morphometric Character	*D. annularis*	*D. cervinus*
Standard length	SL = 0.6567 + 0.7461 TL	SL = 0.1865 + 0.7548 TL
Preanal length	PrA = −3.5512 + 0.5583 TL	PrA = −0.0626 + 0.5194 TL
Preventral length	PrV = 0.506 + 0.2840 TL	PrV = 10.2181 + 0.7067 TL
Predorsal length	PrD = 2.4630 + 0.2566 TL	PrD = 0.2649 + 0.2647 TL
Head length	HL = 3.4510 + 0.2124 TL	HL = −0.3538 + 0.2545 TL
Eye diameter	Ed = 4.0110 + 0.0450 TL	Ed = 0.8417 + 0.0317 TL

S. sargus	*D. vulgaris*
SL = − 2.1885 + 0.7248 TL	SL = − 5.3459 + 0.7760 TL
PrA = − 6.4703 + 0.5614 TL	PrA = − 7.0854 + 0.5388 TL
PrV = − 2.9300 + 0.2975 TL	PrV = 1.0344 + 0.2865 TL
PrD − 2.2050 + 0.2827 TL	PrD = 1.8850 + 0.2571 TL
HL = 1.5091 + 0.2605 TL	HL = 1.3665 + 0.2397 TL
Ed = − 4.0062 + 0.0438 TL	Ed = 4.5257 + 0.0497 TL

Meristic characters

As a support for the morphometric identity, further approach was tried to confirm some specific characters of Alexandria population. Preliminary analysis of data proved that the three selected meristic characters did not show any significant variation with either length or sex of fish examined. Accordingly, all data were considered together.

Dorsal fin spines and rays count

The majority of *D. annularis* examined, about 93 %, had 11 spines and 12 rays in dorsal fin. The same count was also recorded for about 54 % of *D. cervinus* analysed, while in about 27 % of them the count was 11,13. For *D. sargus*, 50 % and 23 % of samples had respectively 13,13 and 11,14 dorsal spines and rays, while in 49 % and 26 % of *D. vulgaris* the count was 11,15 and 11,34 respectively (Table III).

spines and rays	*D. annularis*	N	*D. cervinus*	N
XI , 11	2.64	10	2.7	1
XI , 12	92.61	351	54.05	19
XI , 13	3.96	15	24.32	9
XII , 11	–		13.51	5
XII , 12	0,79	3	2.7	1

Table III. – Dorsal fin spines and rays count (data given in percentage)

Anal fin spines and rays count

Most of fish investigated, about 92 % & 84 % of *D. annularis* and *D. cervinus* respectively, had 3 anal spines and 11 rays, while in 84 % of *D. sargus* and 78 % of *D. vulgaris* examined the count was 3,13 and 3,14 respectively (Table IV).

spines and rays	*D. annularis*	N	*D. cervinus*	N
III , 10	3.17	12	5.41	2
III , 11	91.82	348	83.78	31
III , 12	5.01	19	10.81	4

Table IV. – Anal fin spines and rays count (data given in percentage)

Pyloric caeca

96 % of *D. annularis* and 46 % of *D. cervinus* studied had five pyloric appendages. About 49 % of the latter species had only four pyloric caeca compared with about 70 % of *D. vulgaris* which recorded the same number. As for *D. sargus*, 64 % of specimens analysed had six pyloric caeca (Table V).

no of pyloric caeca	*D. annularis*	N	*D. cervinus*	N
4	0.26	1	48.65	18
5	95.78	363	45.95	17
6	3.69	14	5.41	2
7	0.26	1	–	

Table V. – Pyloric caeca count (data given in percentage)

BIOLOGICAL ANALYSIS

Length/weight relationship and condition factor

The relationship between length and weight of *D. annularis* and *D. cervinus* was calculated according to Lagler (1956). The following formulae were obtained :

$\text{Log } W = -3.8678 + 2.5742 \text{ Log } L$ . . . . for *D. annularis*
$\text{Log } W = -6.5335 + 3.7622 \text{ Log } L$ . . . . for *D. cervinus*

Where W is the total weight in g and L the total length in cm.
These equations can be used to estimate length or weight when only one of these parameters is known. However, equation for *D. cervinus* should be treated with caution since it had been based on a relatively small number of fish (85) as compared with that of *D. annularis* (632).

The weights of *D. cervinus* for a given size group, as shown in Table VI, were generally greater than those of *D. annularis*.

Coefficient of condition was computed using the formula : $K = 100 \text{ W} / \text{L}^3$ (Lagler, 1956), where W is the total weight in g and L the total length in cm. The coefficient of condition value is an expression of the relative condition or « robustness » of fish. These values are usually used to indicate suitability of the environment or to compare fish from different localities.

Condition factor K varied from 1.47 to 2.33 (average 1.95) for *D. annularis* and from 1.47 to 1.98 (av. 1.83) for *D. cervinus*. However, a decreasing trend in the values of K with the increase in length could be detected for *D. annularis*, while K of *D. cervinus* with the exception of 1.47, fluctuated in a narrow range (Table VI).

As regards the monthly variations of K (Fig. 1), highest values for *D. annularis* were observed in August (1.88), January (1.87) and February (1.86), while the

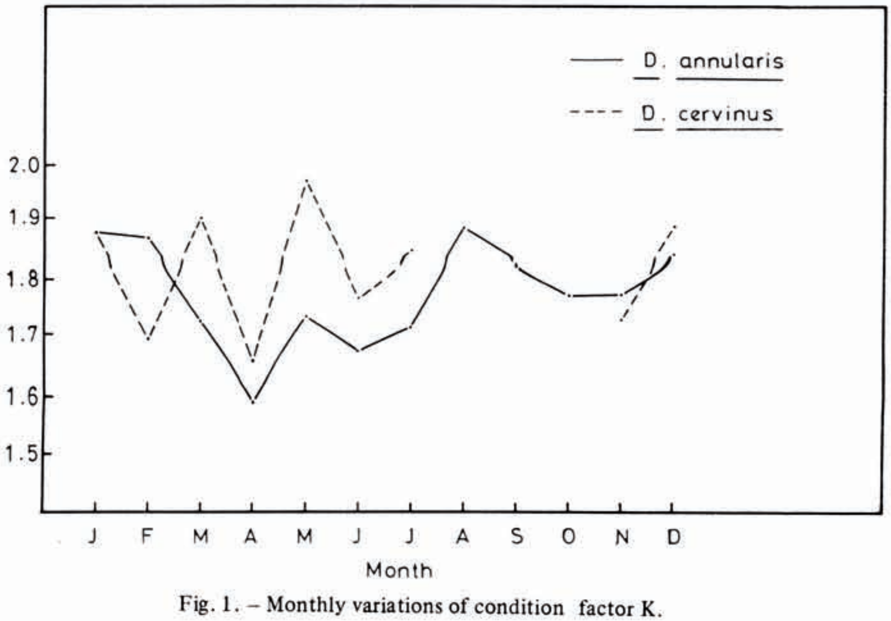

Fig. 1. – Monthly variations of condition factor K.

lowest was recorded in April (1.59). Similarly *D. cervinus* showed minimal condition factor (1.65) in April, but, unfortunately, the gap of data during August, September and October make it difficult for precise interpretation.

Table VI. – Relation between length (L), weight (W) and conditions factor (K) of *D. annularis* and *D. cervinus*. N = number of fish.

mean	*D. annularis*			*D. cervinus*		
L (cm)	W (g)	K	N	W (g)	K	N
7	8.0	2.33	1	–	–	–
8	10.2 ± 0.3	2.0	28	–	–	–
9	13.9 ± 0.2	1.99	86	–	–	–
10	18.8 ± 0.1	1.97	160	–	–	–
11	23.9 ± 0.1	1.90	160	26.0	1.95	1
12	33.2 ± 0.1	2.04	113	30.0	1.74	1
13	38.2 ± 0.1	1.86	50	–		
14	48.2 ± 0.1	1.88	32	52.0	1.9	1
15	55.0 ± 0.1	1.71	19	57.0 ± 1.0	1.78	2
16	61.0 ± 1.0	1.56	2	–		
17	72.0	1.47	1	97.5 ± 0.5	1.98	2
18	–	–	–	100.0 ± 5.9	1.81	3
19	–	–	–	121.3 ± 4.5	1.77	7
20	–	–	–	145.7 ± 9.2	1.87	5
21	–	–	–	166.0 ± 5.4	1.88	3
22	–	–	–	200.5 ± 0.5	1.95	5
23	–	–	–	225.1 ± 4.9	1.9	9
24	–	–	–	251.4 ± 8.5	1.86	6
25	–	–	–	290.5 ± 6.1	1.94	4
26	–	–	–	304.0 ± 9.9	1.79	7
27	–	–	–	340.6 ± 9.9	1.77	10
28	–	–	–	393.8 ± 2.3	1.84	4
29	–	–	–	340.0	1.47	1
30	–	–	–	481.7 ± 4.7	1.81	3
31	–	–	–	539.0 ± 9.3	1.81	3
32	–	–	–	559.0 ± 9.8	1.76	3
33	–	–	–	605.0	1.68	1
34	–	–	–	730.0 ± 4.9	1.86	3
37	–	–	–	860.0	1.7	1
grand average		1.95			1.83	

Growth characteristics of *D. annularis*

As *D. cervinus* is poorly represented in this study, growth estimates were conducted for only *D. annularis*. Scales from 466 specimens were read and these deemed adequate for growth computations.

Fish length/scale radius relationship

The mean total length and average scale radii per 0.5 cm length interval were calculated and the following linear equation was obtained : $L = 2.3368 + 1.3580\,S$, where L is length in cm and S is scale radius (in micrometer division).
A regression line was then plotted (Fig. 2), where the straight line represents the calculated values and the dots the empirical ones. This suggests that scales firstly appeared at length of 2.33 cm.

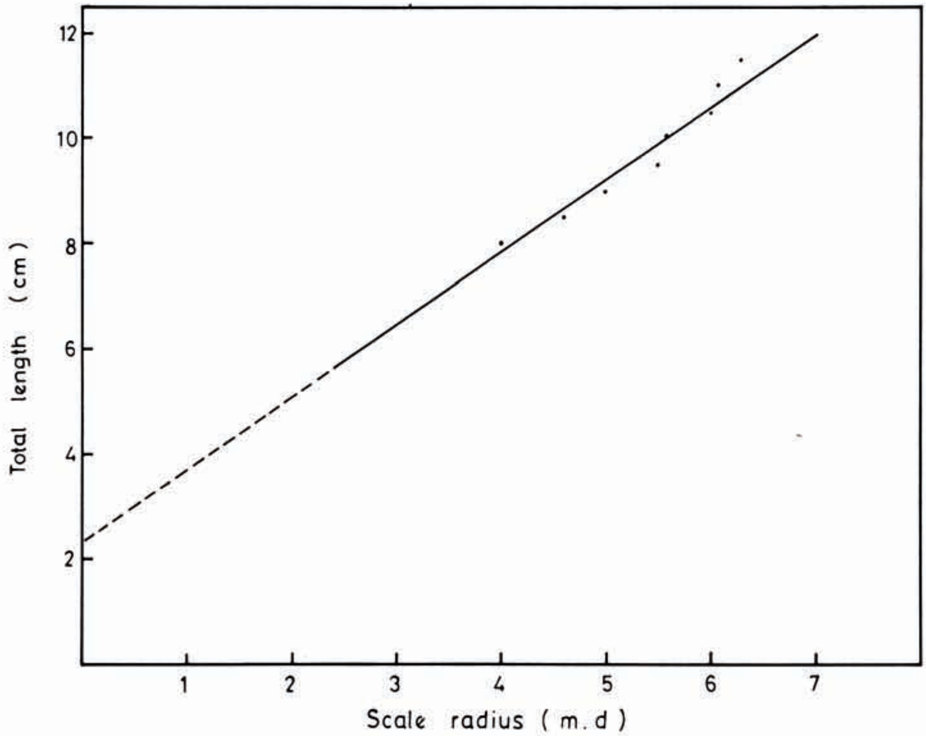

Fig. 2. – Fish length / scale radius relationship for *D. annularis*.

Growth in length

One of the most convenient methods for determining growth rate of an individual fish is to back calculate its lengths at previous ages from relative positions of annuli on its scales (Lagler, 1956). Calculated lengths of *D. annularis* were computed (Table VII), using the formula : $L_n = S_n / S\ (L_t - a) + a$

where L_n = calculated length at the end of year n;
S_n = scale radius to the n^{th} annulus;
S_t = total scale radius;
and a = correction factor (= 2.3368 for *D. annularis*).

group	N	mean L (mm)	L_1	L_2	L_3	L_4	L_5	L_6
I	216	103.18	77.56	–				
II	187	117.17	67.84	102.14 (34.30)	–			
III	25	137.60	69.97	104.39 (34.42)	127.17 (22.78)	–		
IV	10	150.50	74.11	106.19 (32.08)	127.28 (21.09)	143,94 (16.66)	–	
V	1	160.00	60.42	93.62 (33.20)	121.83 (28.21)	141.74 (19.91)	155.02 (13.28)	–
VI	1	170.00	61.02	94.55 (33.53)	119.70 (25.15)	136.47 (16.77)	149.88 (13.41)	161.62 (11.74)
mean	466		72.84	102.38	126.85	143.13	152.45	161.62
mean increment of length			72.84	34.21	22.53	16.94	13.35	11.74

Table VII. – Calculated length at the end of different ages for *D. annularis* (increment in brackets).

A considerable agreement in the average calculated lengths for all age groups could be easily noticed (Table VII). The annual increment of length (B) was highest in the first year, then gradually decreased during the successive years of life (Table VII & Fig. 3). The same trend was also observed for the percentage annual gain (C).

Growth in weight

Calculated weights for the different age groups (Table VIII) were estimated by applying the length-weight equation to the calculated lengths given in Table VII. The annual increment in weight (B) was minimum during the first year of life, then increased in the second and third years and being more or less constant during between the fourth and sixth years of life (Fig. 4).

Growth, in length as well as in weight, of *D. annularis* was compared with those of *D. sargus* and *D. vulgaris*, previously obtained by Wassef (1973), in Fig. 5 and 6 respectively. It is clear that, *D. sargus* showed the highest growth rate in both weight and length, followed by *D. vulgaris* and then *D. annularis*.

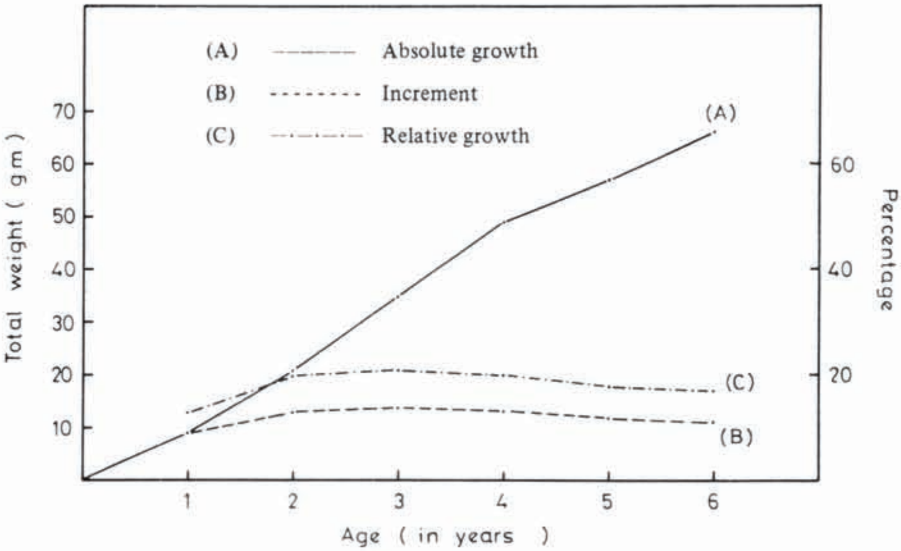

Fig. 4. – Growth in weight with age of *D. annularis*.

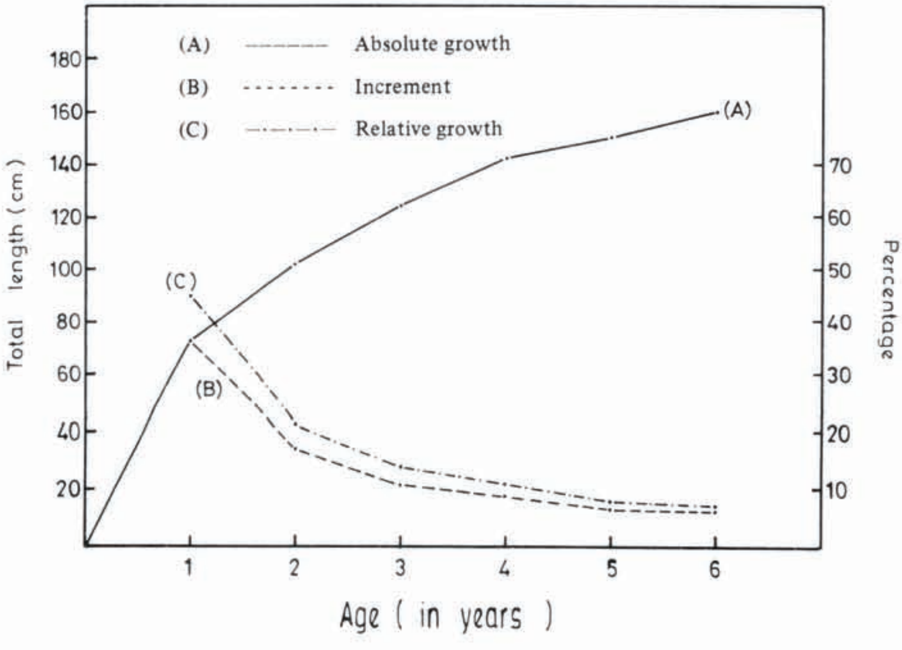

Fig. 3. – Growth in length with age of *D. annularis*.

Age-group	N	W_1	W_2	W_3	W_4	W_5	W_6
I	216	9.919					
II	187	7.028	20.15 (13.122)				
III	25	7.610	21.31 (13.7)	35.42 (14.11)			
IV	10	8.822	22.27 (13.448)	35.5 (13.23)	48.73 (13.23)		
V	1	5.216	16.10 (10.884)	31.72 (15.62)	46.84 (15.12)	58.98 (12.14)	
VI	1	5.351	16.51 (11.159)	30.31 (13.8)	42.48 (12.17)	54.08 (11.6)	65.66 (11.58)
mean	440	8.51	20.34	35.20	48.05	56.53	65.66
mean increment of weight		8.51	13.18	13.9	13.30	11.87	11.58

Table VIII. – Calculated weight (g) at different ages for *D. annularis*

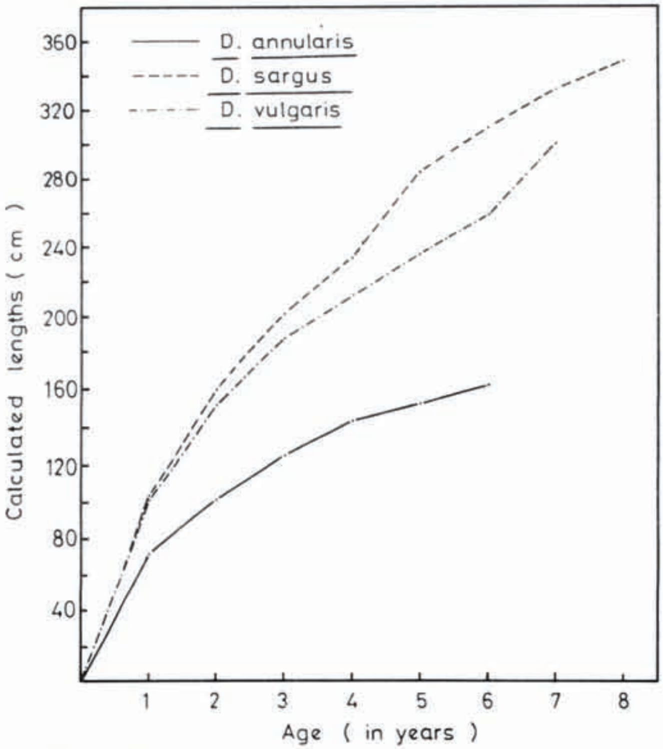

Fig. 5. – Comparison of growth in length for three Diplodus species.

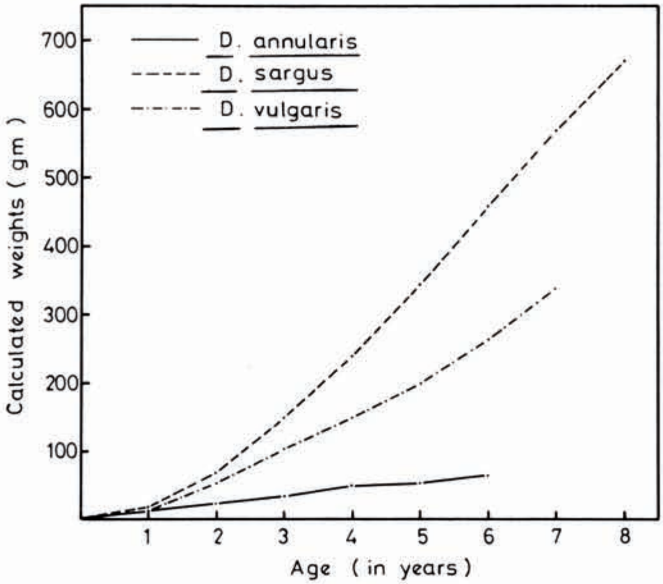

Fig. 6. – Comparison of growth in weight for three Diplodus species.

DISCUSSION

Comparison of the morphometric indices, range and average, for the four local *Diplodus* species (Table I), proved substantial differences from each other. Aproximates values were given by Aloncle (1965) for *D. annularis* inhabiting the Mediterranean coats of Morocco. Kesteven (1950) objected the use of morphometric indices as tools for accurate identification of species and preferred to express the body dimensions in terms of covariance and regression equations, which he proved the validity for marine species. Regression equations derived in the present work indicate that isometric growth occurs between the different parts of the body in relation to total length of *D. annularis* and *D. cervinus*. Wassef (1973) ascertains the same fact for *D. sargus* and *D. vulgaris*. Similar results were also obtained by Aloncle (1965). The result was that Kesteven's view to use regression equation, in defining the morphometric characters of a fish species, is more reliable than the use of indices.

Analysis of length and weight data revealed that the common sizes of *D. annularis* were 11-15 cm and the maximum was 17 cm. The most frequent sizes for *D. cervinus* were 20-27 cm and the maximum was 37 cm. Wassef (1973) collected specimens of *D. sargus* and *D. vulgaris* up to 39 and 30 cm respectively. She mentioned that the majority of the former species varied in length between 15 and 30 cm and the latter 15-25 cm. However, Kamel (1978) recorded a total length of 40 cm for both *D. sargus* and *D. vulgaris*. Comparison of empirical weights, for a given length group, of the four *Diplodus* species pointed out that *D. annularis* was the heavier until length group 14 cm, while for bigger sizes *D. sargus* was always superior in weight followed by *D. cervinus*, then *D. vulgaris* and lastly *D. annularis*. Growth rate curves (Fig. 5 and 6) demonstrated the same trend.

As regards the condition factor, *D. annularis* had the highest average K (1.95), then *D. cervinus* (1.83) in comparison with those of *D. sargus* (1.75) and *D. vulgaris* (1.53), given by Wassef (1973). The decreased values of K of *D. annularis* between April and July may be accompanied with the spawning season which took place in that time. The higher condition during summer months (August and September) may reflect the effect of high temperature on food availability and fish condition. The disappearance of samples during March-April probably related to spawning behaviour where fish become unavailable to the fishermen nets. Salikova (1964) denotes *D. annularis* as protandrous hermaphrodite. Eggs, larvae and young stages were studied by Varagnolo (1964). Recently, Man-Wai and Quignard (1983) have recorded growth rate of *Diplodus sargus* in the Gulf of Lion (France).

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